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(54) Title: RETROREFLECTIVE-COATED AUTOMOTIVE VEHICLE COMPONENTS

(57) Abstract: The present invention provides metallic and/or polymeric automotive vehicle components coated with a retroreflective outer coating deposited from a coating composition comprising one or more crosslinkable film-forming materials and a plurality of retroreflective microsphere beads. Automotive vehicle components coated with retroreflective waterborne basecoats and retroreflective solventborne basecoats applied over electrodeposited coatings are also provided.

RETROREFLECTIVE-COATED AUTOMOTIVE VEHICLE COMPONENTS

5 Cross Reference to Related Patent Application

This patent application is related to U.S. provisional patent application Serial No. 60/137,841 entitled "Retroreflective-Coated Automotive Vehicle Components", filed June 7, 1999.

10 Field of the Invention

The present invention relates to coated automotive vehicle components which have a high quality finish, good daytime appearance and nighttime retroreflectivity.

15 Background of the Invention

Materials reflecting light are well known as a means of increasing the visibility of pedestrians or traffic signs under conditions of reduced visibility. To increase the visibility of automobiles, plastic reflector strips are often mounted in strategic positions on the automobile body. However, these
20 reflectors are aesthetically unattractive and offer only a limited area of reflected light.

U.S. Patent No. 2,963,378 discloses a flat-surfaced reflective colored finish for automobiles in which a coating composition containing hemispherically reflectorized glass microspheroids are mixed with a
25 transparent varnish and volatile solvent and applied as a basecoat. A topcoating of transparent varnish is applied over the basecoat to produce a flat, glossy surface.

It would be desirable to produce automotive vehicle components with a
30 solvents to reduce atmospheric pollution emitted during the painting process.

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Summary of the Invention

The present invention provides a metallic automotive vehicle component having on at least a portion of a surface thereof a retroreflective outer coating deposited from a coating composition comprising: (a) a crosslinkable film-forming material; and (b) a plurality of retroreflective microsphere beads.

Another aspect of the present invention is a metallic automotive vehicle component having on at least a portion of a surface thereof a multi-component composite coating comprising a waterborne basecoat and a clearcoat applied over the basecoat, the waterborne basecoat being deposited from a coating composition comprising: (a) a crosslinkable film-forming material; and (b) a plurality of retroreflective microsphere beads.

Another aspect of the present invention is a metallic automotive vehicle component having on at least a portion of a surface thereof a multi-component composite coating comprising an electrodeposited coating and a retroreflective multicomponent topcoating applied over the electrodeposited coating, the retroreflective multicomponent topcoating comprising a basecoat and a clearcoat applied over the basecoat, the basecoat being deposited from a solventborne basecoating composition comprising: (a) a crosslinkable film-forming material; and (b) a plurality of retroreflective microsphere beads.

Yet another aspect of the present invention is a polymeric automotive vehicle component having on at least a portion of a surface thereof a retro-reflective topcoat deposited from a coating composition comprising: (a) a film-forming material; and (b) a plurality of retroreflective microsphere beads.

Detailed Description of the Preferred Embodiments

The retroreflective-coated automotive vehicle components of the present invention are used to fabricate automotive vehicles, including but not

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limited to automobiles, trucks and tractors. The components can have any shape, but preferably are in the form of automotive body components such as bodies (frames), hoods, doors, fenders, bumpers and/or trim for automotive vehicles.

5 Useful automotive vehicle components include those formed from metal substrates, polymeric substrates, such as thermoset materials and thermoplastic materials, and combinations of metal and polymeric substrates. Suitable metal substrates that can be coated according to the present invention include ferrous metals such as iron, steel, and alloys thereof, non-ferrous metals such as aluminum, zinc, magnesium and alloys thereof, and
10 combinations thereof. Preferably, the substrate is formed from cold rolled steel, electrogalvanized steel such as hot dip electrogalvanized steel or electrogalvanized iron-zinc steel, aluminum or magnesium.

Useful thermoset materials include polyesters, epoxides, phenolics,
15 polyurethanes such as reaction injected molding urethane (RIM) thermoset materials and mixtures thereof. Useful thermoplastic materials include thermoplastic polyolefins such as polyethylene and polypropylene, polyamides such as nylon, thermoplastic polyurethanes, thermoplastic polyesters, acrylic polymers, vinyl polymers, polycarbonates, acrylonitrile-
20 butadiene-styrene (ABS) copolymers, EPDM rubber, copolymers and mixtures thereof.

The present invention first will be discussed generally in the context of a retroreflective-coated metallic automotive vehicle component. One skilled in the art would understand that the process of the present invention also is
25 useful for coating polymeric components, which will be discussed below.

In a preferred embodiment, the metallic automotive vehicle component has on at least a portion of a surface thereof a retroreflective outer coating deposited from a coating composition. Intermediate coatings, which will be

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discussed in detail below, can be present between the surface of the substrate and the retroreflective outer coating, as desired.

The retroreflective outer coating comprises one or more crosslinkable film-forming materials (which will be discussed in detail below) and a plurality of retroreflective microsphere beads at least partially embedded therein. The retroreflective microsphere beads provide the coated automotive vehicle component with retroreflectivity (reflex-reflecting), i.e., the reflecting rays of light are returned in directions close to the opposite of the direction of the incident rays (e.g. along their originating path) with this property being maintained over wide variations in the direction of incident rays.

The microsphere beads generally have an average particle size (equivalent spherical diameter) ranging from about 1 to about 500 micrometers, and preferably about 1 to about 50 micrometers. More preferably, the beads have an average particle size of about 50 microns or less to achieve the highest retroreflectivity and daytime unnoticeability. "Daytime Unnoticeability" refers to the reduced ability of a human eye to detect the retroreflective composition on a surface of a automotive vehicle component and the increased ability to detect the appearance of pigment particles during the period between sunrise and sunset, and while indoors under illuminated conditions. The reduced ability to detect the retroreflective composition during the daytime particularly references a light source of diffuse origin; even in the daytime a beam of focussed light will provide retroreflectivity. "Nighttime" refers to the period of time before sunrise and after sunset or low illuminated indoor conditions. An advantage of the retroreflective-coated metallic automotive vehicle component of the present invention is that the reflective effect is not appreciably noticeable during the daytime.

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The microsphere beads are preferably made from clear glass, silica or barium titanate, although transparent colored glass or mixtures of clear and transparent colored glass beads can be used to provide different visual effects. The microsphere beads can be hollow or solid.

- 5 The microsphere beads preferably are generally hemispherically coated (reflectorized over about half its surface area) with retroreflective means. Retroreflective means include coatings of one or more metallic materials, such as aluminum, or non-metallic materials, such as organic compounds, which enable the microsphere beads to be retroreflective.
- 10 Useful non-metallic coating materials are disclosed in U.S. Patent No. 3,700,305, which is incorporated herein by reference. The retroreflective means can be deposited upon the microsphere beads by passing the beads through a region of a high vacuum deposition chamber wherein a layer of the retroreflective means is deposited over exposed hemispheres of the
- 15 microsphere beads. High vacuum deposition procedures and application methods concerning this process are well known to those skilled in the art. An aluminum deposit of approximately 50 to 250 Angstroms is sufficient to provide an opaque deposit with good reflecting properties. Alternative means of depositing a layer of retroreflective means include sputtering,
- 20 electroplating, spraying, heat transfer or coating.

- The hemispherical reflective coating provides a reflector both for light rays which penetrate the uncoated half of the microspheroid and impinge upon the concave inner surface of the reflective coating and for rays which impinge upon the convex outer surface of the reflective coating. If desired,
- 25 multiple concentric coatings can be applied to the microspheres. A hemispherical color coating can be applied over the reflector coating to impart daytime color to the microbeads.

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The microsphere beads generally have an average index of refraction ranging from about 1.5 to about 2.5, subject to the desired use. Preferably, the microsphere beads having hemispherical reflective means coated thereon have a refractive index of approximately 1.9 to provide efficient retro-
5 reflectivity and daytime unnoticeability. A refractive index of 1.9 provides such retroreflectivity and daytime unnoticeability when the retroreflective microsphere beads are viewed under normal dry conditions. The optimum value for the refractive index of retroreflective microsphere beads is about 2.1 to about 2.5 when the retroreflective microsphere beads are covered with
10 water. Mixtures of microbeads having different indices of refraction can provide enhanced visibility when driving in changing weather conditions.

Non-limiting examples of suitable retroreflective microsphere beads and retroreflective coatings therefor are disclosed in U.S. Patent Nos. 5,650,213; 5,900,978 and 2,963,378 and PCT application WO 99/03007,
15 which are incorporated by reference herein. Preferred retroreflective microsphere beads include IllumiNITE® SataLITE DISH® retroreflective microsphere beads which are commercially available from Reflective Technologies, Inc. of Cambridge, Massachusetts.

In an alternative embodiment, the coating can comprise a plurality of
20 microsphere beads which are not hemispherically coated with a reflective coating, but instead are mixed in the coating with reflective particles such as metal particles or flakes. Non-limiting examples of suitable microsphere beads include glass beads formed from barium titanate such as are commercially available from the Potter division of PQ Corporation and Flex-O-
25 Lite. The average particle size of the beads can range from about 1 to about 500 micrometers, and is preferably about 40 to about 50 micrometers. Examples of suitable reflective particles include aluminum flakes, bronze flakes, coated mica, nickel flakes, tin flakes, silver flakes, copper flakes and

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combinations thereof. Preferably, the average index of refraction of the microsphere beads in this embodiment is about 1.9, although the index can vary as described above.

As discussed above, the retroreflective microsphere beads are present
5 in the retroreflective coating with one or more crosslinkable film-forming materials and, if desired, other additives which will be discussed in detail below. The retroreflective microsphere beads are preferably simply mixed with the other components of the coating composition by stirring until they are well dispersed therein.

10 The type and amount of crosslinkable film-forming material and other components included in the coating composition will depend in part upon the nature of the outer coating and its method of application.

In one embodiment of the present invention, the outer coating is present as an electrodeposited coating formed from an electrodepositable
15 coating composition. Prior to applying the electrodepositable coating composition, the metal substrate can be cleaned and degreased and a pretreatment coating, such as CHEMFOS 700 zinc phosphate or BONA-ZINC zinc-rich pretreatment (each commercially available from PPG Industries, Inc. of Pittsburgh, Pennsylvania), can be deposited upon the surface of the metal
20 substrate. A liquid electrodepositable coating composition comprising one or more crosslinking materials and retroreflective microsphere beads can be applied to a surface of the metal substrate by any suitable anionic or cationic electrodeposition process well known to those skilled in the art. In a cationic electrodeposition process, the liquid electrodepositable coating composition is
25 placed in contact with an electrically conductive anode and an electrically conductive cathode, with the metal surface to be coated being the cathode. Following contact with the liquid electrodepositable coating composition, an adherent film of the coating composition is deposited on the cathode when

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sufficient voltage is impressed between the electrodes. The applied voltages can be varied and generally range from about 1 to about several thousand volts. The current density is usually between about 0.5 and about 15 amperes per square foot and tends to decrease during electrodeposition
5 indicating the formation of an insulating film.

Useful electrodepositable coating compositions generally comprise one or more crosslinkable film-forming materials and crosslinking materials. As used herein, "film-forming", means that the film-forming materials form a self-supporting continuous film on at least a horizontal surface of the substrate
10 upon removal of any solvents or carriers present in the film-forming composition or curing at ambient or elevated temperature. As used herein, "crosslinkable" means that the film-forming materials can be self-crosslinking or crosslinked by reaction with suitable crosslinking materials included in the coating composition. Suitable film-forming materials include epoxy-functional
15 film-forming materials, polyurethane film-forming materials, acrylic film-forming materials and mixtures thereof. The amount of film-forming material in the electrodepositable composition generally ranges from about 50 to about 95 weight percent on a basis of total weight solids of the electrodepositable composition.

20 Suitable epoxy-functional materials contain at least one, and preferably two or more, epoxy or oxirane groups in the molecule, such as di- or polyglycidyl ethers of polyhydric alcohols which can be aromatic (such as bisphenol A), aliphatic (such as glycols or polyols) or cycloaliphatic. Suitable epoxy-functional materials have an epoxy equivalent weight ranging from
25 about 100 to about 2000, as measured by titration with perchloric acid using methyl violet as an indicator. Useful epoxy-functional materials are disclosed in U.S. Patent No. 5,820,987 at column 4, line 52 through column 6, line 59, which is incorporated by reference herein. The epoxy-functional material can

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be reacted with an amine or sulfide to form cationic salt groups to facilitate dispersion in aqueous media. Suitable acrylic-functional film-forming materials include polymers derived from alkyl esters of acrylic acid and methacrylic acid such as are disclosed in U.S. Patent Nos. 3,455,806 and 3,928,157, which are incorporated herein by reference. Useful crosslinking materials comprise blocked or unblocked polyisocyanates including aromatic diisocyanates; aliphatic diisocyanates such as 1,6-hexamethylene diisocyanate; and cycloaliphatic diisocyanates such as isophorone diisocyanate and 4,4'-methylene-bis(cyclohexyl isocyanate). Examples of suitable blocking agents for the polyisocyanates include lower aliphatic alcohols such as methanol, oximes such as methyl ethyl ketoxime and lactams such as caprolactam. The amount of the crosslinking material in the electrodepositable coating composition generally ranges from about 5 to about 50 weight percent on a basis of total resin solids weight of the electrodepositable coating composition.

Generally, the electrodepositable coating composition also comprises one or more pigments which can be incorporated in the form of a paste, surfactants, wetting agents, catalysts, film build additives, flatting agents, defoamers, microgels, pH control additives and volatile materials such as water and organic solvents, as described in U.S. Patent No. 5,820,987 at column 9, line 13 through column 10, line 27. Useful solvents included in the composition, in addition to any provided by other coating components, include coalescing solvents such as hydrocarbons, alcohols, esters, ethers and ketones which are generally present in an amount of about 0.05 to about 5 weight percent on a basis of total weight of the electrodepositable coating composition.

Other useful electrodepositable coating compositions are disclosed in U.S. Patent Nos. 4,891,111; 4,933,056 and 5,760,107, which are

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incorporated herein by reference. The solids content of the liquid electrodepositable coating composition generally ranges from about 3 to about 75 weight percent, and preferably about 5 to about 50 weight percent.

If the electrodepositable coating composition is applied by immersing
5 the metal substrate into a bath, after removing the substrate from the bath the substrate is exposed to air to permit excess electrodeposited coating composition to drain from the interior cavities and surfaces of the substrate, and then dried and cured using a conventional hot air convection or infrared oven. The thickness of the electrodeposited coating applied to the substrate
10 generally ranges from about 5 to about 40 micrometers.

In an alternative preferred embodiment, the outer coating which includes the retroreflective microsphere beads is a monocoat which is applied over an electrodeposited coating and/or primer (which do not contain retroreflective microsphere beads). The primer coating composition can be
15 liquid, powder slurry (powder dispersed in liquid) or powder (solid). The liquid or powder slurry primer coating can be applied to the surface of the substrate by any suitable coating process well known to those skilled in the art, for example by dip coating, direct roll coating, reverse roll coating, curtain coating, spray coating, brush coating and combinations thereof. Powder
20 coatings are generally applied by electrostatic deposition. The liquid or powder slurry primer coating composition generally comprises one or more film-forming materials, volatile materials and, optionally, pigments. Volatile materials are not present in the powder coating composition. Preferably, the primer coating composition, whether liquid, powder slurry or powder,
25 comprises one or more thermosetting film-forming materials, such as polyurethanes, acrylics, polyesters, epoxies and crosslinking materials such as aminoplasts (discussed below) and/or polyisocyanates (discussed above).

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Suitable polyurethane film-forming materials include the reaction products of polymeric polyols such as polyester polyols or acrylic polyols with a polyisocyanate such as are discussed above. Suitable acrylic polymers include polymers of acrylic acid, methacrylic acid and alkyl esters thereof.

5 Other useful film-forming materials and other components for primers are disclosed in U.S. Patent Nos. 4,971,837; 5,262,464 and 5,492,731, which are incorporated herein by reference. The amount of film-forming material in the primer generally ranges from about 5 to about 60 weight percent on a basis of total resin solids weight of the primer coating composition. The amount of the

10 crosslinking material in the primer generally ranges from about 5 to about 50 weight percent on a basis of total resin solids weight of the primer coating composition.

Volatile materials which can be included in the liquid or powder slurry primer coating composition include water and/or organic solvents, such as

15 alcohols; ethers and ether alcohols; ketones; esters; aliphatic and alicyclic hydrocarbons; and aromatic hydrocarbons. The amount of volatile material in the primer coating composition can range from about 1 to about 30 weight percent on a total weight basis of the primer coating composition. Other additives, such as plasticizers, antioxidants, mildewcides, fungicides,

20 surfactants, fillers and pigments, can be present in the primer coating composition in amounts generally up to about 40 weight percent. Useful fillers and pigments are disclosed in U.S. Patent No. 4,971,837, which is incorporated herein by reference. For the liquid and powder slurry primer coating compositions, the weight percent solids of the coating generally

25 ranges from about 30 to about 80 weight percent on a total weight basis.

The monocoat outer coating which includes the retroreflective microsphere beads can be applied over the electrodeposited coating or primer coating, if present, by any conventional coating process such as are

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discussed above for applying the primer. The monocoat can be applied as a liquid, powder slurry or powder. In addition to the retroreflective microsphere beads, the monocoat comprises one or more crosslinkable film-forming materials and, optionally, crosslinking materials, volatile materials and pigment. Preferably, the monocoating composition is a crosslinkable coating composition comprising one or more thermosettable film-forming materials, such as acrylics, polyesters (including alkyds), polyurethanes and epoxies, and one or more crosslinking materials, examples of which are discussed above. The amount of film-forming material in the liquid monocoating composition generally ranges from about 40 to about 97 weight percent on a basis of total weight solids of the monocoating composition.

Suitable acrylic polymers include copolymers of one or more of acrylic acid, methacrylic acid and alkyl esters thereof, such as methyl methacrylate, ethyl methacrylate, hydroxyethyl methacrylate, butyl methacrylate, ethyl acrylate, hydroxyethyl acrylate, butyl acrylate and 2-ethylhexyl acrylate, optionally together with one or more other polymerizable ethylenically unsaturated monomers including vinyl aromatic compounds such as styrene and vinyl toluene, nitriles such as acrylonitrile and methacrylonitrile, vinyl and vinylidene halides, and vinyl esters such as vinyl acetate. Other suitable acrylics and methods for preparing the same are disclosed in U.S. Patent No. 5,196,485 at column 11, lines 16-60, which are incorporated herein by reference.

Polyesters and alkyds are other examples of resinous binders useful for preparing the monocoating composition. Such polymers can be prepared in a known manner by condensation of polyhydric alcohols, such as ethylene glycol, propylene glycol, butylene glycol, 1,6-hexylene glycol, neopentyl glycol, trimethylolpropane and pentaerythritol, with polycarboxylic acids such

as adipic acid, maleic acid, fumaric acid, phthalic acids, trimellitic acid or drying oil fatty acids.

Suitable crosslinking materials include aminoplasts, polyisocyanates, polyacids, polyanhydrides and mixtures thereof. Useful aminoplast resins are based on the addition products of formaldehyde, with an amino- or amido-
5 group carrying substance. Condensation products obtained from the reaction of alcohols and formaldehyde with melamine, urea or benzoguanamine are most common. Useful polyisocyanate crosslinking materials are discussed above. The amount of the crosslinking material in the basecoat coating
10 composition generally ranges from about 5 to about 50 weight percent on a basis of total resin solids weight of the monocoating composition.

The liquid monocoating composition comprises one or more volatile materials such as water, organic solvents and/or amines. Nonlimiting examples of useful solvents included in the composition, in addition to any
15 provided by other coating components, include aliphatic solvents such as hexane, naphtha, and mineral spirits; aromatic and/or alkylated aromatic solvents such as toluene, xylene, and SOLVESSO 100; alcohols such as ethyl, methyl, n-propyl, isopropyl, n-butyl, isobutyl and amyl alcohol, and m-pyrol; esters such as ethyl acetate, n-butyl acetate, isobutyl acetate and
20 isobutyl isobutyrate; ketones such as acetone, methyl ethyl ketone, methyl isobutyl ketone, diisobutyl ketone, methyl n-amyl ketone, and isophorone, glycol ethers and glycol ether esters such as ethylene glycol monobutyl ether, diethylene glycol monobutyl ether, ethylene glycol monohexyl ether, propylene glycol monomethyl ether, propylene glycol monopropyl ether,
25 ethylene glycol monobutyl ether acetate, propylene glycol monomethyl ether acetate, and dipropylene glycol monomethyl ether acetate. Useful amines include alkanolamines. The solids content of the liquid monocoating composition generally ranges from about 15 to about 60 weight percent.

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The monocoating composition can further comprise one or more pigments or other additives such as UV absorbers, rheology control agents or surfactants. Useful metallic pigments include aluminum flake, bronze flakes, coated mica, nickel flakes, tin flakes, silver flakes, copper flakes and combinations thereof. Other suitable pigments include mica, iron oxides, lead oxides, carbon black, titanium dioxide and colored organic pigments such as phthalocyanines. In one embodiment, the pigment particles are blue, and comprise copper phthalocyanine blue, indanthrone blue, or carbazole violet. In another embodiment, the pigment particles are yellow, and comprise monoarylide yellow (i.e. pigment yellow 1 (Hansa Yellow G), pigment yellow 65, pigment yellow 73, pigment yellow 74), diarylide yellow, benzimidazoline yellow, or heterocyclic yellow. Transparent pigment particles, as compared to opaque pigment particles, yield improved retroreflectivity under nighttime conditions. Fluorescent or phosphorescent dyes also can be used to provide daytime visibility, if desired. Untreated glass beads in combination with pigments can be included in the coating composition, if desired.

Preferably, the pigment particles have a diameter of less than about 2 microns, and more preferably less than about 1 micron. Pigment particles less than about 1 micron will uniformly coat the automotive vehicle component in a continuous manner. The small size of the pigment particle enables the pigment to bond directly to the substrate. A pigment particle with a diameter of less than 2 microns, which is substantially smaller than the size of the microsphere beads of the present invention, does not deter retroreflection at nighttime and enhances daytime unnoticeability while providing flexibility. Further, with a pigment particle having a diameter of less than 2 microns, microspheres of 50 microns will not prevent any of the pigment particles from moving within the coating during application. Thus, even if two microsphere beads of 50 microns are adjacent to each other, the

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pigment particles will have sufficient space to lodge between the microsphere beads, or gather below and/or on the top surface of the microsphere beads, to provide sufficient pigment throughout the substrate's surface. A pigment particle having a size greater than 2 microns could interfere with a light
5 source from contacting the microsphere bead at nighttime and prevent the return of the retroreflective rays. With pigment particles less than 2 microns, the pigment particles do not appreciably interfere with the retroreflective properties.

The specific pigment to binder ratio can vary widely so long as it
10 provides the requisite hiding at the desired film thickness and application solids. The relative amounts of the ingredients of the retroreflective composition of the present invention will, of course, vary depending upon the particular ingredients employed, the type of substrate, the substrates intended use, as well as such factors as the specific size and quantity of the
15 retroreflective microsphere beads.

In yet another alternative preferred embodiment, the outer coating which includes the retroreflective microsphere beads can be a clearcoat which is applied over a basecoat which does not contain retroreflective microsphere beads. The components of the basecoat can be any of those
20 discussed above for the monocoat. Preferably, the basecoat comprises one or more crosslinkable film forming materials, crosslinking materials and pigments such as are discussed above. A preferred crosslinkable film-forming material is an aqueous dispersion of polymeric microparticles prepared by polymerizing ethylenically unsaturated monomers, such as alkyl
25 esters of acrylic and methacrylic acids and vinyl aromatics, in the presence of a substantially hydrophobic polymer such as a polyester or polyurethane. Suitable waterborne basecoats for color-plus-clear composites include those disclosed in U.S. Patent Nos. 4,403,003; 5,071,904 and 5,401,790, which are

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incorporated by reference herein. Also, waterborne polyurethanes such as those prepared in accordance with U.S. Patent No. 4,147,679 can be used as the resinous film former in the basecoat, which is incorporated by reference herein. Suitable film formers for organic solvent-based base coats are
5 disclosed in U.S. Patent No. 4,220,679 at column 2, line 24 through column 4, line 40 and U.S. Patent No. 5,196,485 at column 11, line 7 through column 13, line 22, which are incorporated by reference herein. The thickness of the basecoating composition applied to the substrate generally ranges from about 10 to about 38 micrometers. The dried basecoat that is formed upon the
10 surface of the automotive vehicle component is dried sufficiently to enable application of a topcoat such that the quality of the topcoat will not be affected adversely by further drying of the basecoat.

The clearcoating composition can be liquid, powder or powder slurry and can be applied over the basecoat in any conventional manner such as is
15 discussed above for applying the primer. The clearcoating composition comprises the retroreflective microsphere beads and one or more crosslinkable film-forming materials. Useful film-forming materials include epoxy-functional film-forming materials, acrylics, polyesters, polyamides, polyethers and/or polyurethanes, such as are discussed above. The
20 clearcoating composition can include additives such as are discussed above for the basecoat, but preferably not pigments. If the clearcoating is a liquid or powder slurry, volatile material(s) are included.

Suitable waterborne clearcoats are disclosed in U.S. Patent No. 5,098,947 (incorporated by reference herein) and are based on water soluble
25 acrylic resins. Useful solvent borne clearcoats are disclosed in U.S. Patent Nos. 5,196,485 and 5,814,410 (incorporated by reference herein) and include epoxy-functional materials and polyacid curing agents. Suitable powder clearcoats are described in U.S. Patent No. 5,663,240 (incorporated by

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reference herein) and include epoxy functional acrylic copolymers and polycarboxylic acid crosslinking agents, such as dodecanedioic acid. The amount of the clearcoating composition applied to the substrate can vary based upon such factors as the type of substrate and intended use of the substrate, i.e., the environment in which the substrate is to be placed and the nature of the contacting materials.

In another alternative embodiment, the outer coating can be a refinish coating comprising one or more crosslinkable film-forming materials and retroreflective microsphere beads which are applied over a damaged cured topcoat, for example to repair an imperfection in the cured paint coating of an automobile. Refinish coatings are generally curable at lower temperatures than original equipment coatings, preferably at less than about 75°C within about four hours. Suitable crosslinkable film-forming materials for refinish coatings include hydroxy components having at least two free hydroxyl groups per molecule, such as simple diols, triol, and higher hydric alcohols, acrylic polyols, polyester polyols, polyether polyols, amide-containing polyols, epoxy polyols, polyhydric polyvinyl alcohols, cellulose and derivatives thereof, urethane polyols and mixtures thereof. Useful crosslinking materials include isocyanates such as are discussed above or anhydride components having at least two carboxylic acid anhydride groups per molecule, such as can be derived from an ethylenically unsaturated carboxylic acid anhydride and vinyl comonomers. Pigments and other additives such as are discussed above for the basecoat can also be included in the refinish coating composition. Suitable refinish coating components are disclosed in U.S. Patent No. 4,798,745, which is incorporated by reference herein.

In another alternative embodiment, the metallic automotive vehicle component can be coated with a topcoat or multi-component composite coating which comprises a waterborne basecoat (including retroreflective

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microsphere beads) and a clearcoat (with or without retroreflective microsphere beads) applied over the basecoat. The waterborne basecoating composition comprises one or more crosslinkable film-forming materials and the plurality of retroreflective microsphere beads. Suitable crosslinkable film-forming materials and other components of the basecoat, such as crosslinking materials and pigments, are discussed in detail above, as well as suitable components for the clearcoat.

In another alternative embodiment, the metallic automotive vehicle component can be coated with a multi-component composite coating comprising an electrodeposited coating and a retroreflective multicomponent topcoating applied over the electrodeposited coating. The retroreflective multicomponent topcoating comprises a basecoat and a clearcoat applied over the basecoat. The basecoat is deposited from a solventborne basecoating composition comprising one or more crosslinkable film-forming materials and a plurality of retroreflective microsphere beads. Retroreflective microsphere beads also can be included in the clearcoat, if desired. Suitable components for the solventborne basecoat and clearcoat (solventborne, waterborne or powder) are discussed in detail above.

In another alternative embodiment according to the present invention, a polymeric automotive vehicle component is coated with a retroreflective outer coating deposited from a coating composition comprising one or more film-forming materials and a plurality of retroreflective microsphere beads. Suitable polymeric substrates are discussed in detail above. The outer coating can be applied over a coating of an adhesion promoter such as a modified chlorinated polyolefin. Suitable adhesion promoters for application to polymeric substrates are disclosed in U.S. Patent Nos. 4,997,882 and 5,397,602, which are incorporated by reference herein. The other components of the outer coating, such as the crosslinkable film-forming

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material and optional components such as crosslinking materials and pigments, include those disclosed above as suitable for use in the monocoat.

Whether the retroreflective microsphere beads are used in an outer coating (electrocoat, monocoat or topcoat) or other coating discussed above, the microsphere beads are generally randomly oriented in the coating. When retroreflective microsphere beads are applied to the automotive vehicle component, they randomly orient themselves with respect to the plane of its surface, providing for retroreflection at a wider range of angles. The large number of beads in a given area provide sufficient reflectance such that an observer cannot distinguish the rays being reflected from a single microbead and the overall effect is generally uniform.

The amount of retroreflective microsphere beads included in the coating compositions described above can vary depending upon the average diameter of the beads and the amount and particle size of other components, such as pigments, in the coating compositions. Generally, the amount of retroreflective microsphere beads included in the coating compositions is that which is sufficient to provide nighttime retroreflectivity of the coated automotive vehicle component. "Semi-Saturated Microspheric Density" refers to the number of retroreflective microsphere beads per unit of area required to be deposited on the automotive vehicle component to yield daytime unnoticeability and nighttime retroreflectivity of the resulting substrate.

The actual number of microsphere beads in a one dimensional space depends on the diameter of the microsphere beads. The optimum microsphere size to achieve the highest retroreflectivity and daytime unnoticeability, and for obtaining optimum coatability, dispersion and suspension in the coating composition is approximately 50 micrometers in diameter. At 50 micrometers, the maximum number of microspheres which

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may be deposited in a coating layer is approximately 46,000 microsphere beads per square centimeter.

In embodiments in which the retroreflective coating contains pigment, it is preferable to maintain a relationship of volume ratio of discrete insoluble particles within the composition. This volume ratio is independent of any volatile content (if used) in the composition, for it is only the non-volatile ingredients which remain on the automotive vehicle component after evaporation of the volatile ingredients. Further, among the non-volatile ingredients, only the dried and cured residue of the crosslinked film-forming materials and additives, the retroreflective microsphere beads, and the pigment particles compose the retroreflective composition having the volume ratio identified above. A useful concept to describe this volume ratio requirement is the ratio of the volume of the dried and cured crosslinked film-forming materials and additives (film-former solids) to the volume of retroreflective microsphere beads and pigment particles. This ratio, referred to herein as the Film-Former Solids-To-Bead+Pigment Volume Concentration ("FBPVC") ranges from greater than zero percent to about 99,000%, preferably between about 50% to about 10,000%, and more preferably about 50% to about 185%.

Generally, it is preferred to provide a thin layer of coating composition that does not interfere with a source of light reaching the back surface of the microsphere beads upon which the retroreflective means is coated. When the layer of coating composition through which a source of light must pass is thick, the beam of light will be refracted thus preventing an adequate retroreflection of light. However, a sufficient amount of coating composition must be applied to insure the retroreflective microsphere beads are secured firmly to the automotive vehicle component. Also, sufficient pigment particle coverage over the entire surface area of the desired portion of the automotive vehicle component must be provided to satisfy aesthetic requirements.

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Preferably, the coating composition layer has a thickness of less than one half, and more preferably less than about one quarter, of the average diameter of a microsphere bead to provide good reflectance.

The retroreflective-coated automotive vehicle components of the present invention can have one or more of the following desirable retroreflective attributes: detectability, conspicuity, recognizability, and localizability. These criteria are based on the physiological visual responses that a driver requires to perceive and respond to a potential hazard. Thus, the process by which the eye, brain, and body react to a potentially hazardous situation can be characterized through the four previously mentioned criteria. It is important to recognize that unlike automotive components using traditional retroreflective strips, an automotive component that reflects a full silhouette provides additional conspicuity, recognizability, and localizability.

"Detectability" refers to the characteristic of an object that determines the likelihood that the object will be visible to an observer. For example, when a driver is approaching a sign, the sign will become detectable when the driver's eyes are first capable of seeing it. However, at this point the driver may not have noticed the sign and will not have registered that he is viewing it.

"Conspicuity" refers to the characteristic of an object that determines the likelihood that the object will come to the attention of the observer. Since one's eyes continuously detect millions of objects, conspicuity implies that the mind has registered the importance of this object and begun to consider it.

"Recognizability" refers to the characteristic of an object that determines the likelihood that the object will be recognized by an observer. Upon recognition of an object, the motorist can determine whether it is worthy

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of potential action by identifying whether the object is a sign, another automobile, a person, an animal, or something else.

"Localizability" refers to the characteristic of an object that determines the likelihood an observer will be able to determine the object's location.

- 5 Localizability enables a driver to judge the size and position of the object to determine whether the object appears capable of intersecting with the vehicle's path (by mentally judging the closing rate, necessary deceleration, and lateral offset).

- The retroreflectivity of the automotive vehicle component preferably is
- 10 not increased to the extent that the retroreflective microsphere beads provide a silvery or colored appearance on the substrate during daytime viewing conditions. Preferably, a maximum of 20,000 microspheric beads per square centimeter applied to the automotive vehicle component provides the maximum degree of daytime unnoticeability of the automotive vehicle
- 15 component. This correlates to a retroreflectivity per area of 45 candelas per lux per square meter, and a retroreflectivity of less than 4.0 candelas per lux per automotive vehicle component. "Reflectivity per area ratio" is a ratio that represents the degree of retroreflectivity of a substrate upon which retroreflective microsphere beads are deposited. The ratio is dependent upon
- 20 the angle between the light source, the substrate and the observer. The ratio can be measured in the units of candelas per lux per meter squared. "Reflectivity per automotive vehicle component" is a ratio that represents the retroreflectivity of the automotive vehicle component. The measurement is an average of the retroreflectivity of the automotive vehicle component measured
- 25 at each orientation as the automotive vehicle component is rotated in 15% increments. This test has been modified from the standard ASTM industry test. This ratio is calculated from the average of the ratios measured at a distance of both 70 meters and 230 meters between the observer and the

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automotive vehicle component and can be measured in units of average candelas per lux per automotive vehicle component. "Candelas" is a unit of luminous intensity equal to one sixtieth of the luminous intensity of one square centimeter of a blackbody surface at the solidification temperature of platinum. The candela is used for the measurement of retroreflectivity, i.e. candelas per lux per square meter, or candelas per lux per automotive vehicle component.

As a result, a trade-off must be made for each individual automotive vehicle component depending on its intended use. The density, or number of microsphere beads per square centimeter, determines both the degree of retroreflectivity and the degree of daytime unnoticeability of the automotive vehicle component. For use in the present invention, the optimal number of retroreflective microsphere beads per square centimeter of automotive vehicle component or the semi-saturated microspheric density of automotive vehicle component is between about 2,000 and about 20,000. A semi-saturated microspheric density of between 2,000 and 20,000 results in a retroreflectivity per area of 3 to 45 candelas per lux per square meter, and in retroreflectivity per automotive vehicle component of 0.10 to 3.00 candelas per lux per automotive vehicle component.

For certain automotive vehicle components, particularly automotive vehicle components having indentations, microsphere beads having a semi-saturated microspheric density will tend to gather on the upper surfaces of the lower lodged retroreflective microsphere beads and subsequently group together to form multiple layers of retroreflective microsphere beads, or multi-tiered microsphere beads. "Multi-Tiered Microspheres" refers to the structure of microsphere beads which results from the semi-saturated microspheric density of the present invention. Specifically, when approximately 2,000 to 20,000 microsphere beads are deposited onto a

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square centimeter of automotive vehicle component, a portion of the microsphere beads will tend to gather on the upper surfaces of the lower lodged retroreflective microsphere beads and subsequently group together to form multiple layers of retroreflective microsphere beads, or multi-tiered
5 microsphere beads. The advantages of multi-tiered microsphere beads are that they improve overall reflectivity of the substrate while maintaining desired levels of daytime unnoticeability. In some embodiments, 10% to 50% of the beaded substrate surface has formations of 2 to 3 layers of microspheres. Actual percentages vary with the type of automotive vehicle component used.

10 The multi-tiered microspheres can deposit in the recesses of the automotive vehicle component. However, since reflectivity depends largely on the orientation of the retroreflectively coated microsphere beads, the multi-tiered microsphere beads which are randomly oriented increase the likelihood that a beam of light will be reflected back to its source. Further, the
15 ability of the less than 2 micron diameter pigment particles to lodge themselves in the crevices and surface area of the coating assists in the daytime unnoticeability of the retroreflective composition.

The small size of the retroreflective microsphere beads coupled with the multi-tiered microsphere beads assist in preventing the observer's eyes
20 from resolving the silvery or colored retroreflective means coated on the microsphere beads under daytime viewing conditions. Rather, the observer sees the surface area of the coating interposed between the retroreflective microsphere beads. This surface area predominantly includes the pigment particles. Thus, the retroreflective composition achieves its daytime
25 unnoticeability to enable an observer to see only the color of the pigment on the automotive vehicle component. This effect is primarily achieved because the retroreflective microsphere beads having an index of refraction of approximately 1.9 is viewed by diffused light during the day. Thus, only a

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small proportion of these diffuse light rays which impact the retroreflective microsphere beads are directed in the proper direction to be reflected at the back surfaces of the retroreflective microsphere beads so as to reach the observer's eyes. Only those rays which are incident in paths close to the observer's line of sight will be viewed. The incident light rays striking the outer exposed surfaces of the coating are largely absorbed by the pigment particles in the coating.

However, when viewed at nighttime, there is minimum diffuse light directed on the automotive vehicle component. Rather, at nighttime, there are focussed illuminating rays, such as headlights or flashlights, directed at the automotive vehicle component. These rays are incident in substantially the same direction as the observer's line of sight. As a result of these focus incident rays, a brilliant silvery or colored reflection occurs for those rays striking the retroreflective microsphere beads. The intensity drowns out the effect of the exposed surface area of the coating. The automotive vehicle component appears as though it is fully coated with a brilliant silvery or colored paint. Thus, the difference in day and night appearance result from the optical effects produced by the retroreflective composition of the present invention.

Further, the deposition of microsphere beads in 2-3 layers increases the angularity of nighttime reflectivity. Because of the random orientation and multiple layering of the microsphere beads, there are more retroreflective microsphere beads located at higher elevations on the automotive vehicle component and at different orientations that are available to reflect light which strikes the coated automotive vehicle component, even at such angles as 135°. This is especially beneficial when children, pedestrians, bicyclists, or other automobiles approach the road perpendicular to the direction the automobile is traveling.

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The present invention will be described further by reference to the following examples. The following examples are merely illustrative of the invention and are not intended to be limiting. Unless otherwise indicated, all parts are by weight.

5

EXAMPLES

An aqueous, unpigmented coating composition was prepared by first mixing the components shown in Table 1 ("Premix A") for 15 minutes.

10

Table 1

Component	Amount (grams)
Ethylene glycol monohexyl ether	261.6
Ethylene glycol monohexyl ether	88
TINUVIN 1130 ¹	24
Phosphatized Epoxy ²	7.8
CYMEL® 327 ³	177.8
50% Aqueous DMEA	8.8

Premix A was then added to the premixed components of Table 2 to produce the aqueous, unpigmented coating composition. The pH of the composition was adjusted to 8.65 using an appropriate amount of 50% aqueous dimethyl ethanolamine (DMEA) solution. The composition was then reduced to a spray viscosity of approximately 35 seconds (#4 DIN Cup) with deionized water.

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¹ Substituted benzotriazole UV light absorber from Ciba Additives.

² Phosphatized epoxy prepared from EPON® 828, a polyglycidyl ether of Bisphenol A, available from Shell Oil and Chemical Co. reacted with phosphoric acid at an 83:17 weight ratio.

³ Partially methylated melamine resin available from CYTEC Industries, Inc.

Table 2

Component	Amount (grams)
Premix A	568
Latex ⁴	558.1
SHELLSOL® D255	80
Polyurethane/acrylic dispersion ⁶	640
Polyacrylic dispersion EPL 6920 ⁷	664
Ethylene glycol monohexyl ether	88.8
Deionized Water	1060

Coating Compositions 1, 2 and 3:

Aqueous clearcoating compositions according to the present invention
 5 were prepared by adding 50 micrometer average particle size IllumiNITE®
 SataLITE DISH® retroreflective microsphere beads (commercially available
 from Reflective Technologies, Inc. of Cambridge, Massachusetts) to the
 aqueous unpigmented coating composition described above in the amounts
 shown in Table 3. The components were added together under agitation and
 10 the mixture was allowed to stir for 15 minutes until well dispersed.

⁴ Prepared according to U.S. Patent 5,510,148, see Example 1.

⁵ Mineral spirits available from Shell Chemical Co.

⁶ The polyurethane/acrylic dispersion was prepared as follows: a polyurethane prepolymer was prepared by blending dimethylolpropionic acid (34.9 parts); DESMODUR® W methylene-bis-(4-cyclohexyl diisocyanate (140.3 parts, available from Bayer Corp.); DDI 1410 dimer isocyanate (81.3 parts, available from Henkel Corp.); FORMREZ® 66-56 1,6-hexanediol adipate (199.5 parts available from Witco Corp.); MPEG 2000 methoxy polyethylene glycol (50.3 parts available from Union Carbide, Inc.); dibutyltin dilaurate (0.4 parts); and N-methyl pyrrolidone (130.2 parts) and heated at 90°C until the NCO equivalent weight reached 1079. The prepolymer was cooled to 35°C and methyl methacrylate (197.9 parts), butyl acrylate (136.8 parts), and ethylene glycol dimethacrylate (14.0 parts) were added, followed by N,N-dimethylethanolamine (23.2 parts). This mixture was dispersed into deionized water (2372.1 parts) containing diethylenetriamine (18.7 parts) at 40°C over 20 minutes and was held at 40°C for 15 minutes. The dispersion was passed through a MICROFLUIDIZER® emulsifier at 8000 psi and was then heated to 60°C. A solution of ammonium persulfate (1.28 parts) in deionized water (99.4 parts) was slowly added, and the temperature was adjusted to 80°C and held for 30 minutes. The resulting polymer dispersion had a solids content of approximately 25 percent.

⁷ Polyacrylic dispersion EPL 6920 available from Akzo Nobel.

Table 3

Example No.	Amount of Coating Composition (grams)	Amount of retroreflective microsphere beads (grams)
1	114.73	6.3
2	114.73	12.5
3	114.73	18.8

Tint Paste:

- Polyacrylic grind resin⁸ (176.5 grams), BYK®-031 defoamer (1.56 grams, available from Byk-Chemie) and deionized water (18 grams) were added together and agitated with a Cowels blade for 10 minutes. Chlorinated copper phthalocyanine blue pigment was added to the mixture until a pigment to binder ratio of 1.98 was achieved. An adequate amount of 50% aqueous dimethyl ethanolamine was added until a pH of 8.5 was achieved. The mixture was agitated with a Cowels blade for 15 minutes. The resultant paste was passed through a media mill until the mean particle size fell below 0.8 micrometers.

⁸ The polyacrylic grind resin was prepared as follows: a reaction vessel equipped with a stirrer, condenser, temperature probe, addition funnels and nitrogen sparge tube was charged with 78.0 grams of DOWANOL PM propylene glycol monoethyl ether (available from Dow Chemical Company) and 28.1 grams of PROPASOL P propylene glycol monopropyl ether (available from Dow) and was heated to reflux (about 120°C). Two feeds, identified herein as "Feed A" and "Feed B" were added gradually to the vessel. Feed A was added over a period of 3.5 hours. Feed B was added over a period of 3 hours and was started 15 minutes after Feed A. Feed A consisted of a mixture of 14.8 grams of tert-butyl peroxyacetate (50% mineral spirit solution) and 48.2 grams of DOWANOL PM propylene glycol monoethyl ether (available from Dow). Feed B consisted of 49.9 grams styrene, 143.8 grams butyl acrylate, 213.8 grams methyl methacrylate, 49.9 grams hydroxyethyl acrylate and 39.6 grams acrylic acid. After the addition of Feed A was complete, the mixture was allowed to hold for one hour. The reaction was cooled to 100°C and 48.8 grams of dimethyl ethanolamine was added. The mixture was allowed to stir for 15 minutes. To the reaction vessel, 1292.8 grams of deionized water at a temperature of 70°C was added over a period of 10 minutes.

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Application:

Steel panels coated with ED5000 electrocoat and GPXH5379 primer available from ACT Laboratories Inc. were spray coated with an aqueous basecoat prepared from 7.8 grams of the tint paste mixed for 15 minutes with
5 114.73 grams of the aqueous unpigmented coating composition described above. The aqueous basecoat was applied at ambient temperature (about 25°C) and humidity conditions (about 60% relative humidity) using an automated paint sprayer. The paint was applied at a sufficient thickness to achieve hiding over the primer (about 15 micrometers). The coated panels
10 were ambient flashed for 5 minutes and then baked in an oven for 10 minutes at 80°C (176°F).

The panels were coated with the clearcoating Compositions 1-3 using an automated paint sprayer at ambient temperature and humidity. Two coats of clearcoat were applied (film thickness unknown due to the large diameter
15 of the retroreflective microsphere beads). The panels were flashed at ambient temperature for 5 minutes and then baked in an oven for 10 minutes at 80°C (176°F). Each of these coated panels reflected direct and diffused light. As the concentration of the retroreflective microsphere beads increased, the reflectance also increased.

20 The panels were then overcoated with approximately 45 micrometers thickness of WTKR 2000 solventborne two component isocyanate clearcoat commercially available from PPG Industries, Inc. of Pittsburgh, Pennsylvania. The overcoat was applied using an automated paint sprayer. The panels were allowed an ambient flash for 10 minutes and then a 30-minute cure in an
25 oven at 141°C (285°F). Once coated with the overcoat, the coatings lost most of their reflectance.

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Coating Composition 4:

A tinted monocoating composition according to the present invention was prepared by mixing 7.8 grams of the tint paste described above and 86.7 grams of 50 micrometer average particle size IllumiNITE® SataLITE DISH®
5 retroreflective microsphere beads (commercially available from Reflective Technologies, Inc. of Cambridge, Massachusetts) under agitation, to 114.5 grams of the aqueous unpigmented coating composition. The mixture was allowed to stir for 15 minutes until well dispersed.

A 4"x 12" cold rolled steel panel available from ACT Laboratories Inc.
10 was spray coated with the monocoat described above at ambient temperature and humidity. Two coats were applied with a 30 second ambient flash between the coats (film thickness unknown due to the large diameter of the retroreflective microsphere beads). The panel was then allowed an ambient flash for 5 minutes and baked in an oven for 10 minutes at 80°C (176°F). The
15 panel was able to reflect direct and diffused light and displayed a blue hue.

The panel was then masked so that only half of the panel was exposed. The exposed portion of the panel was overcoated with approximately 45 micrometers of WTKR 2000 solventborne two component isocyanate clearcoat commercially available from PPG Industries, Inc. using
20 an automated paint sprayer. The panel was allowed an ambient flash for 10 minutes and cured for 30 minutes in an oven at 141°C (285°F). The reflecting ability of the half of the overcoated panel was dramatically reduced in comparison to the uncoated half.

25 It will be appreciated by those skilled in the art that changes could be made to the embodiments described above without departing from the broad inventive concept thereof. It is understood, therefore, that this invention is not limited to the particular embodiments disclosed, but it is intended to cover

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modifications that are within the spirit and scope of the invention, as defined by the appended claims.

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THEREFORE, WE CLAIM:

1. A metallic automotive vehicle component having on at least a portion of a surface thereof a retroreflective outer coating deposited from a coating composition comprising:
 - (a) a crosslinkable film-forming material; and
 - (b) a plurality of retroreflective microsphere beads.
2. The automotive vehicle component according to claim 1, wherein the component is formed from a metallic material selected from the group consisting of iron, steel, aluminum, zinc, magnesium, alloys and combinations thereof.
3. The automotive vehicle component according to claim 1, wherein the outer coating is an electrodeposited coating.
4. The automotive vehicle component according to claim 1, wherein the outer coating is a monocoat.
5. The automotive vehicle component according to claim 1, wherein the outer coating is a clearcoat applied over a basecoat.
6. The automotive vehicle component according to claim 1, wherein the outer coating is a refinish coating.

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7. The automotive vehicle component according to claim 1, wherein the crosslinkable film-forming material is selected from the group consisting of polyesters, polyurethanes, acrylic polymers, polyamides, polyethers and copolymers and mixtures thereof.

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8. The automotive vehicle component according to claim 7, wherein the crosslinkable film-forming material is an aqueous dispersion of polymeric microparticles prepared by polymerizing ethylenically unsaturated monomers in the presence of a substantially hydrophobic polymer selected from the group consisting of polyesters and polyurethanes.

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9. The automotive vehicle component according to claim 1, wherein the crosslinkable film-forming material is present in an amount ranging from about 25 to about 100 weight percent on a basis of total resin solids of the coating composition.

15

10. The automotive vehicle component according to claim 1, wherein the retroreflective microsphere beads have an average particle size ranging from about 1 to about 500 micrometers.

20

11. The automotive vehicle component according to claim 1, wherein the retroreflective microsphere beads are generally hemispherically coated with a coating composition which enables the microsphere beads to be retroreflective in the outer coating on the automotive vehicle component.

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12. The automotive vehicle component according to claim 1, wherein the outer coating has a semi-saturated microspheric density ranging from about 20 to about 20,000 microspheric beads per square millimeter of automotive vehicle component.

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13. The automotive vehicle component according to claim 1, wherein the coating composition further comprises a crosslinking material capable of reacting with the crosslinkable film-forming material to form a crosslinked outer coating.

10

14. The automotive vehicle component according to claim 1, wherein the coating composition further comprises a volatile material.

15. The automotive vehicle component according to claim 1, wherein the coating composition is a waterborne coating composition.

15

16. The automotive vehicle component according to claim 1, wherein the coating composition is a solventborne coating composition.

17. The automotive vehicle component according to claim 1, wherein the coating composition is a powder coating composition.

20

18. A metallic automotive vehicle component having on at least a portion of a surface thereof a multi-component composite coating comprising a waterborne basecoat and a clearcoat applied over the basecoat, the waterborne basecoat being deposited from a coating composition comprising:

25

- (a) a crosslinkable film-forming material; and
- (b) a plurality of retroreflective microsphere beads.

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19. The automotive vehicle component according to claim 18,
wherein the component is formed from a metallic material selected from the
group consisting of iron, steel, aluminum, zinc, magnesium, alloys and
5 combinations thereof.

20. The automotive vehicle component according to claim 18,
wherein the crosslinkable film-forming material is selected from the group
consisting of polyesters, polyurethanes, acrylic polymers, polyamides,
10 polyethers and copolymers and mixtures thereof.

21. The automotive vehicle component according to claim 20,
wherein the crosslinkable film-forming material is an aqueous dispersion of
polymeric microparticles prepared by polymerizing ethylenically unsaturated
15 monomers in the presence of a substantially hydrophobic polymer selected
from the group consisting of polyesters and polyurethanes.

22. The automotive vehicle component according to claim 18,
wherein the crosslinkable film-forming material is present in an amount
20 ranging from about 25 to about 100 weight percent on a basis of total resin
solids of the coating composition.

23. The automotive vehicle component according to claim 18,
wherein the retroreflective microsphere beads have an average spherical
25 diameter ranging from about 1 to about 500 micrometers.

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24. The automotive vehicle component according to claim 18,
wherein the retroreflective microsphere beads are generally hemispherically
coated with a coating composition which enables the microsphere beads to
be retroreflective in the multi-component composite coating on the automotive
5 vehicle component.

25. The automotive vehicle component according to claim 18,
wherein the multi-component composite coating has a semi-saturated
microspheric density ranging from about 20 to about 20,000 microspheric
10 beads per square millimeter of automotive vehicle component.

26. The automotive vehicle component according to claim 18,
wherein the coating composition further comprises a crosslinking material.
crosslinking material capable of reacting with the crosslinkable film-forming
15 material to form a crosslinked outer coating.

27. The automotive vehicle component according to claim 18,
wherein the coating composition further comprises a volatile material.

20 28. A metallic automotive vehicle component having on at least a
portion of a surface thereof a multi-component composite coating comprising
an electrodeposited coating and a retroreflective multicomponent topcoating
applied over the electrodeposited coating, the retroreflective multicomponent
topcoating comprising a basecoat and a clearcoat applied over the basecoat,
25 the basecoat being deposited from a solventborne basecoating composition
comprising:

- (a) a crosslinkable film-forming material; and
- (b) a plurality of retroreflective microsphere beads.

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29. The metallic automotive vehicle component according to claim 28, wherein the component is formed from a metallic material selected from the group consisting of iron, steel, aluminum, zinc, magnesium, alloys
5 and combinations thereof.

30. The automotive vehicle component according to claim 28, wherein the crosslinkable film-forming material is selected from the group consisting of polyesters, polyurethanes, acrylic polymers, polyamides,
10 polyethers and copolymers and mixtures thereof.

31. The automotive vehicle component according to claim 28, wherein the crosslinkable film-forming material is present in an amount ranging from about 25 to about 100 weight percent on a basis of total resin
15 solids of the coating composition.

32. The automotive vehicle component according to claim 28, wherein the retroreflective microsphere beads have an average spherical diameter ranging from about 1 to about 500 micrometers.
20

33. The automotive vehicle component according to claim 28, wherein the retroreflective microsphere beads are generally hemispherically coated with a coating composition which enables the microsphere beads to be retroreflective in the multi-component composite coating on the automotive
25 vehicle component.

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34. The automotive vehicle component according to claim 28, wherein the multi-component composite coating has a semi-saturated microspheric density ranging from about 20 to about 20,000 microspheric beads per square millimeter of automotive vehicle component.

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35. The automotive vehicle component according to claim 28, wherein the coating composition further comprises a crosslinking material. crosslinking material capable of reacting with the crosslinkable film-forming material to form a crosslinked outer coating.

10

36. The automotive vehicle component according to claim 28, wherein the coating composition further comprises a volatile material.

37. A polymeric automotive vehicle component having on at least a portion of a surface thereof a retroreflective topcoat deposited from a coating composition comprising:

15

- (a) a film-forming material; and
- (b) a plurality of retroreflective microsphere beads.

38. The polymeric automotive vehicle component according to claim 37, wherein the component is formed from a thermoset polymeric material selected from the group consisting of thermoset polyesters, epoxides, phenolics, thermoset polyurethanes and combinations thereof.

20

39. The polymeric automotive vehicle component according to claim 37, wherein the component is formed from a thermoplastic polymeric material selected from the group consisting of polyolefins, polyamides,

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thermoplastic polyurethanes, thermoplastic polyesters, acrylic polymers, vinyl polymers, polycarbonates, copolymers and mixtures thereof.

40. The polymeric automotive vehicle component according to
5 claim 37, wherein the retroreflective topcoat is a monocoat.

41. The polymeric automotive vehicle component according to
claim 37, wherein the retroreflective topcoat is a multicomponent coating
which comprises a clearcoat applied over a basecoat.
10

42. The polymeric automotive vehicle component according to
claim 37, wherein the clearcoat comprises the coating composition.

43. The polymeric automotive vehicle component according to
15 claim 37, wherein the basecoat comprises the coating composition.

44. The automotive vehicle component according to claim 37,
wherein the crosslinkable film-forming material is selected from the group
consisting of polyesters, polyurethanes, acrylic polymers, polyamides,
20 polyethers and copolymers and mixtures thereof.

45. The automotive vehicle component according to claim 37,
wherein the crosslinkable film-forming material is present in an amount
ranging from about 25 to about 100 weight percent on a basis of total resin
25 solids of the coating composition.

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46. The automotive vehicle component according to claim 37, wherein the retroreflective microsphere beads have an average spherical diameter ranging from about 20 to about 200 micrometers.

5 47. The automotive vehicle component according to claim 37, wherein the retroreflective microsphere beads are generally hemispherically coated with a coating composition which enables the microsphere beads to be retroreflective in the topcoat on the automotive vehicle component.

10 48. The automotive vehicle component according to claim 37, wherein the topcoat has a semi-saturated microspheric density ranging from about 20 to about 20,000 microspheric beads per square millimeter of automotive vehicle component.

15 49. The automotive vehicle component according to claim 37, wherein the coating composition further comprises a crosslinking material, crosslinking material capable of reacting with the crosslinkable film-forming material to form a crosslinked topcoat.

20 50. The automotive vehicle component according to claim 37, wherein the coating composition further comprises a volatile material.

25 51. The automotive vehicle component according to claim 37, wherein the coating composition is a waterborne coating composition.

52. The automotive vehicle component according to claim 37, wherein the coating composition is a solventborne coating composition.

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53. The automotive vehicle component according to claim 37, wherein the coating composition is a powder coating composition.

54. An automotive vehicle component having on at least a portion of
5 a surface thereof a retroreflective coating deposited from a coating composition comprising:

- (a) a crosslinkable film-forming material;
- (b) a plurality of microsphere beads; and
- (c) a plurality of reflective particles.

10